U.S. Naval Research Laboratory

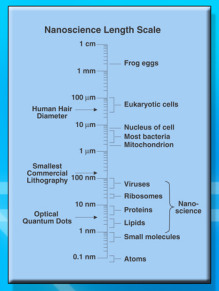
Institute for Nanoscience

The U.S. Navy, known for its enormous aircraft carriers and nuclear submarines, now has the opportunity to exploit the world of the very small for its next generation of technology. Future technology will be increasingly based upon materials and devices fabricated at the atomic scale (measured in nanometers – billionths of a meter). And because it understands both nanoscience and the needs of the Navy, NRL is uniquely positioned to bring that knowledge to bear to benefit our warfighters and our nation.

Toward increasing that understanding, NRL has established an Institute for Nanoscience to conduct multidisciplinary research at the intersection of the fields of materials, electronics, and biology at the nanometer length scale. The Institute serves as NRL's nucleus of collaborative activity in this rapidly evolving research area.

The Institute is seen as a venue to bring together scientists with disparate training and backgrounds to attack common goals at the intersection of their respective fields. The Institute provides scientific leadership for the Navy and DOD to identify and exploit those cross-disciplinary opportunities at this length scale that had been previously inaccessible.

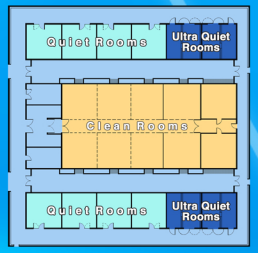
In support of this new initiative, NRL has constructed a major new facility at its Washington, DC location. The new facility, opened in October 2003, is administered by the Institute Director. It uses approximately 5,000 square feet of Class 100 fabrication clean rooms and an equal area of specialized, vibrationally and acoustically quiet and ultra-quiet laboratory space to carry out research in this demanding regime, under very carefully controlled conditions.



Current Programs

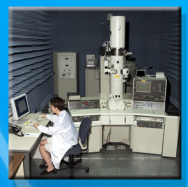
- Nanomaterials
  - Nanofilaments: interfacial interactions, manipulation, and assembly
  - Chemically functionalized carbon nanotubes
  - Nanostructured catalyst architectures for improved fuel cell performance
  - Synthetic nanopores for stochastic sensing of ions, small molecules, and macromolecules
- Nano-optics, Opto-electronic, and Nano-mechanical Devices
  - Nanomechanical resonators and advanced nanodynamics
  - Coherence, correlation, and control in nano-structures
  - Nanoengineered photovoltaic devices
  - Integration of nanostructured light emitting devices
  - Photonic crystal optoelectronic components in advanced materials
  - Quantum dot single photon devices
  - Supramolecular photoelectronic nanodevice based on artificial photosynthetic model
  - Quantum dot materials for non-linear optics
  - Integrated nanomechanical device arrays
- Nano-, Bio-, and Molecular Electronics
  - Assembly of laterally coupled molecular nanostructures
  - Nanocluster electronics by macro-molecular templating
  - Interfacing electronics and bio-molecular processes
  - Integrated molecular nanostructures
  - Chemical and biological assembly of nanocluster-based electronics/sensors

Facilities



4000 SQ FT USEABLE SPACE
CLEAN ROOMS 5000 sf; DM 3200 sf; UQR 1800 sf

Field Emission Transmission Electron Microscope



Electron Beam Lithography

Reactive Ion Etching Systems

Wafer Inspection Station

Ion Beam Deposition

Metrology

Optical Mask Aligners

Electron-Beam Evaporation System

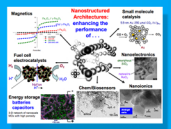
4-Probe UHV STM and Nano-manipulator

Scanning Electron Microscope

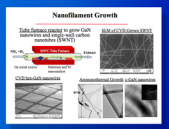
Focused Ion Beam Work Station

Recent Successes

Nanomaterials



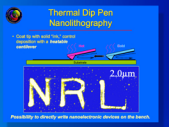
Nanoarchitectures constructed by combining electrically conducting nanostructured solids with nanoscale pores and channels amplify incredibly the nature of the surface, while ensuring molecular transport paths. The exploration of such multifunctional composites of "being and nothing-ness" is causing us to rethink the design of materials and structures in the next generation of electrochemical power sources and other materials applications.



Carbon nanotubes have been grown and selectively deposited by a dielectrophoresis method and under magnetic control. Crystalline GaN nanowires have been grown by a catalyst-free method.

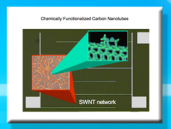
Instrumentation Research, Metrology, and Standards for Nanotechnology

Completed the development and installation of unique-in-the-world Nanomanipulation and Characterization Facility.

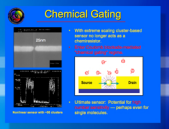


Introduced a new model describing the writing mechanism for Dip Pen Nanolithography (DPN) and also invented the thermal DPN (tDPN) method in which nanostructures can be deposited or written directly onto a substrate by heating the tip of the device.

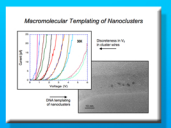
Nanoscale Devices and Systems



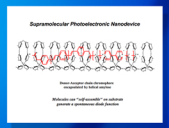
Networks of carbon nanotubes are developed for extremely sensitive, low-power sensor arrays to detect and identify chemical and biological agents.



Gold nanocluster particles are used to develop novel single electron devices and chemical sensors.

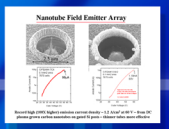


NRL has used DNA and rigid-rod polymer templates to self-assemble nanocluster "wires."

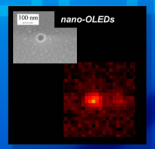


Successfully synthesized an important photo electro-active donor-acceptor chain chromophore combined with helical amylace for incorporation into photoelectronic (i.e., light-harvesting) devices.

Nanomechanical resonators have been fabricated from silicon and diamond for advanced acoustic applications.



A CNT-based field emitter array achieved record high (100x) emission current density of 1.2 A/cm² at 60V.



Miniature OLEDs, some as small as 60 nanometers across, may prove useful for quantum communication or in photopatterning nanomaterials. The OLEDs rely on a light-emitting polymer called MEH-PPV. The polymer is packed inside cylindrical nanoholes etched about 100 nanometers deep into a film of silicon nitride. Each cylinder acts as an independent OLED. Tests showed that the nanodiode's electrical and light-emitting properties are much like those of a larger reference OLED.